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Human-Automation Collaboration Taxonomy (HACT)

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Outline

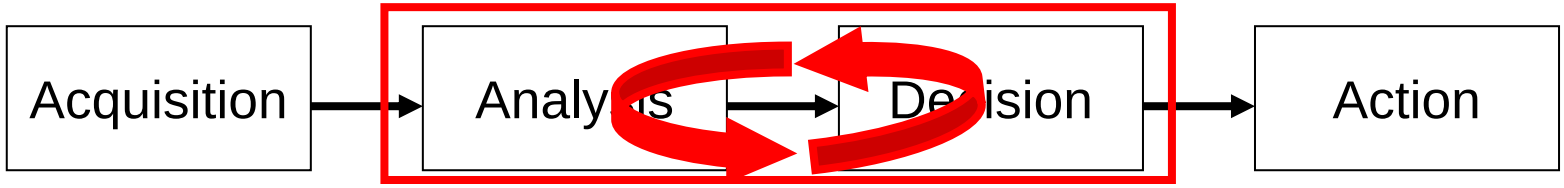
- Human-Computer Collaboration
- Motivation
- A Revised Decision-Making Process Model
- HACT Framework
- HACT Visualization
- Case Study - StrikeView

Definition and Scope

- "Mutual engagement of agents in a coordinated and synchronous effort to solve a problem based on a shared conception of it." *(adapted from Dillenbourg et al. 1995)*

- Agents:
  - One human operator, and
  - One automated system

- Application:
  - Collaborative Human-Computer Decision-Making (CHCDM)
  - Analysis and Decision-Making steps of information processing



(Parasuraman, Sheridan et al. 2000)

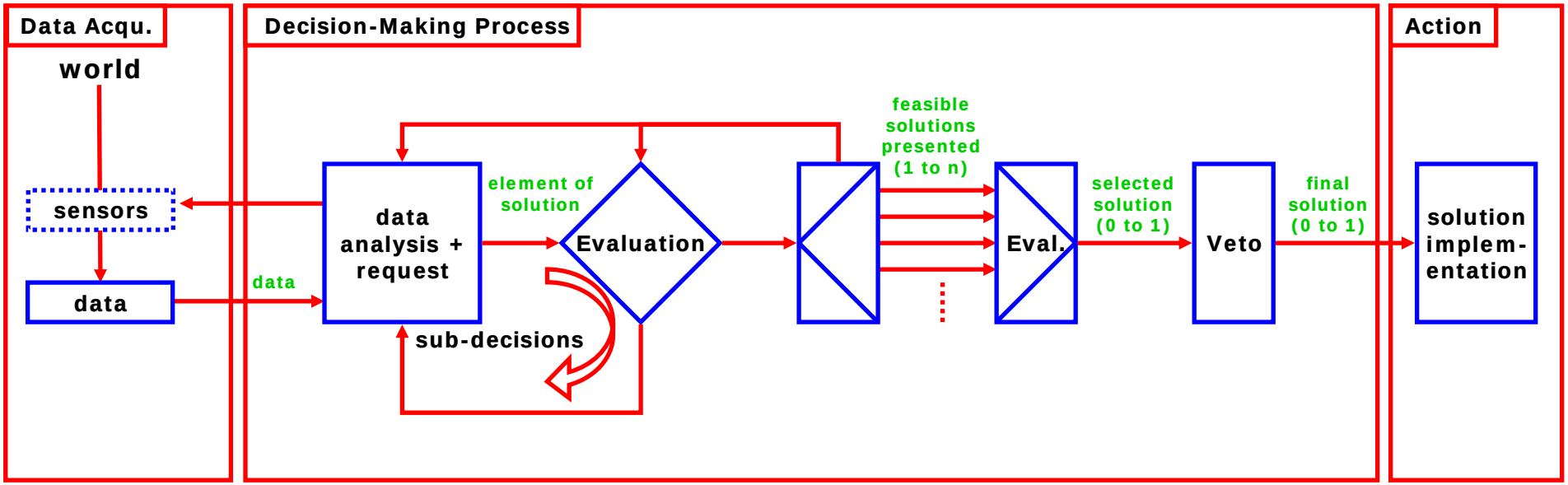
Existing frameworks

- Sheridan and Verplank (1978), Parasuraman et al. (2001):
  - 10-point LOA scale
  - from fully manual to fully automated
- Endsley (1987): 5-point LOA scale for Artificial Intelligence
- Riley (1989): level of information vs. level of authority
- Endsley and Kaber (1999):
  - 10-point LOA scale
  - levels of automation for 4 different functions

Issues

- no inclusion of alternate modes of communication (feedback, iteration etc…)
- no differentiation between solution generation and choice
- lack the notions of transparency, how information is exchanged, how LOAs can change over time

A Revised Decision-Making Process Model



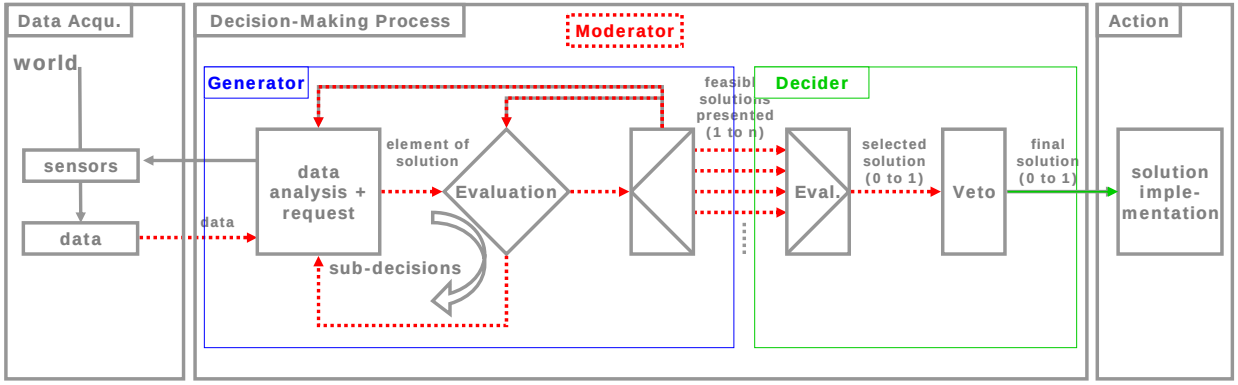
HACT: Human-Automation Collaboration Taxonomy

- Structure:
  - Basic roles
    - The moderator
    - The generator
    - The decider
  - Primary characteristics
    - Functional transparency
    - Information transparency
    - Interactivity
  - Secondary meta-characteristic
    - Adaptability

The Moderator

- **Who keeps the decision process moving forward?**
- Examples: interaction initiation, process pace

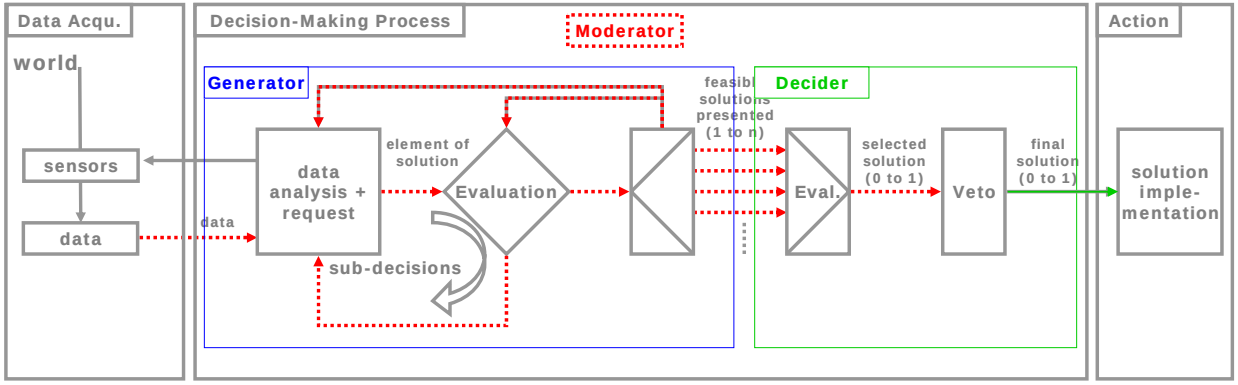
Moderator Level	Who assumes the role of Moderator?
1	Human
2	Mixed, but more human
3	Hybrid
4	Mixed but more automation
5	Automation



The Generator

- **Who generates feasible solutions?**
- Examples: searching, identifying, creating solutions or parts of it

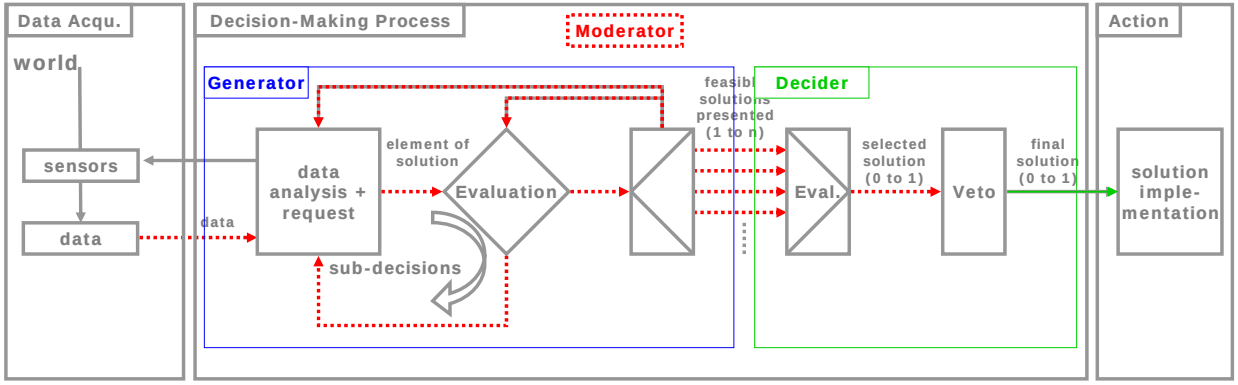
Generator Level	Who assumes the role of Generator?
1	Human
2	Mixed, but more human
3	Hybrid
4	Mixed but more automation
5	Automation



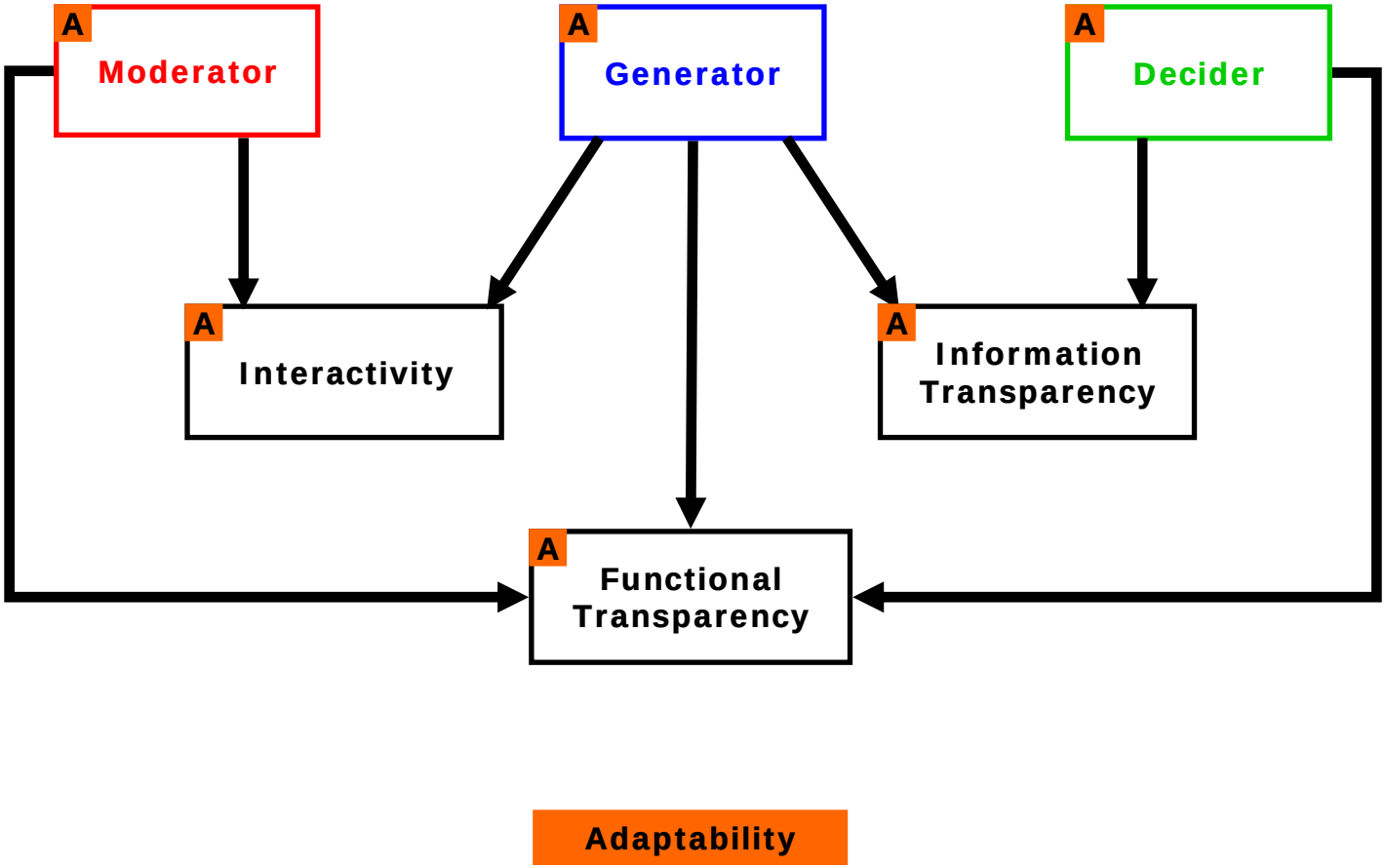
The Decider

- **Who makes the final decision?**
- Examples: selecting the final solution, vetoing the final solution

Decider Level	Who assumes the role of Decider?
1	Human makes final decision, automation cannot veto
2	Human or automation can make final decision, human can veto, automation cannot
3	Human or automation can make final decision, human and automation can veto
4	Human or automation can make final decision, human cannot veto, automation can
5	Automation makes final decision, human cannot veto



Relations between roles and characteristics



Functional Transparency

- **How does the system provide feedback to the human about the way automation works?**
- Applies to: Moderator, Generator, Decider

Functional Transparency Level	Description
Black	The system is opaque ("black box"): the human operator has no means to understand how the automation works.
Grey	The system has features allowing the human operator to obtain a partial representation of the automation's internal process.
White	The system has features allowing the human operator to obtain a complete representation of the automation's internal process ("white box").

Information Transparency

- **What type of information is being presented and used by the agents?**
- Applies to: Generator, Decider

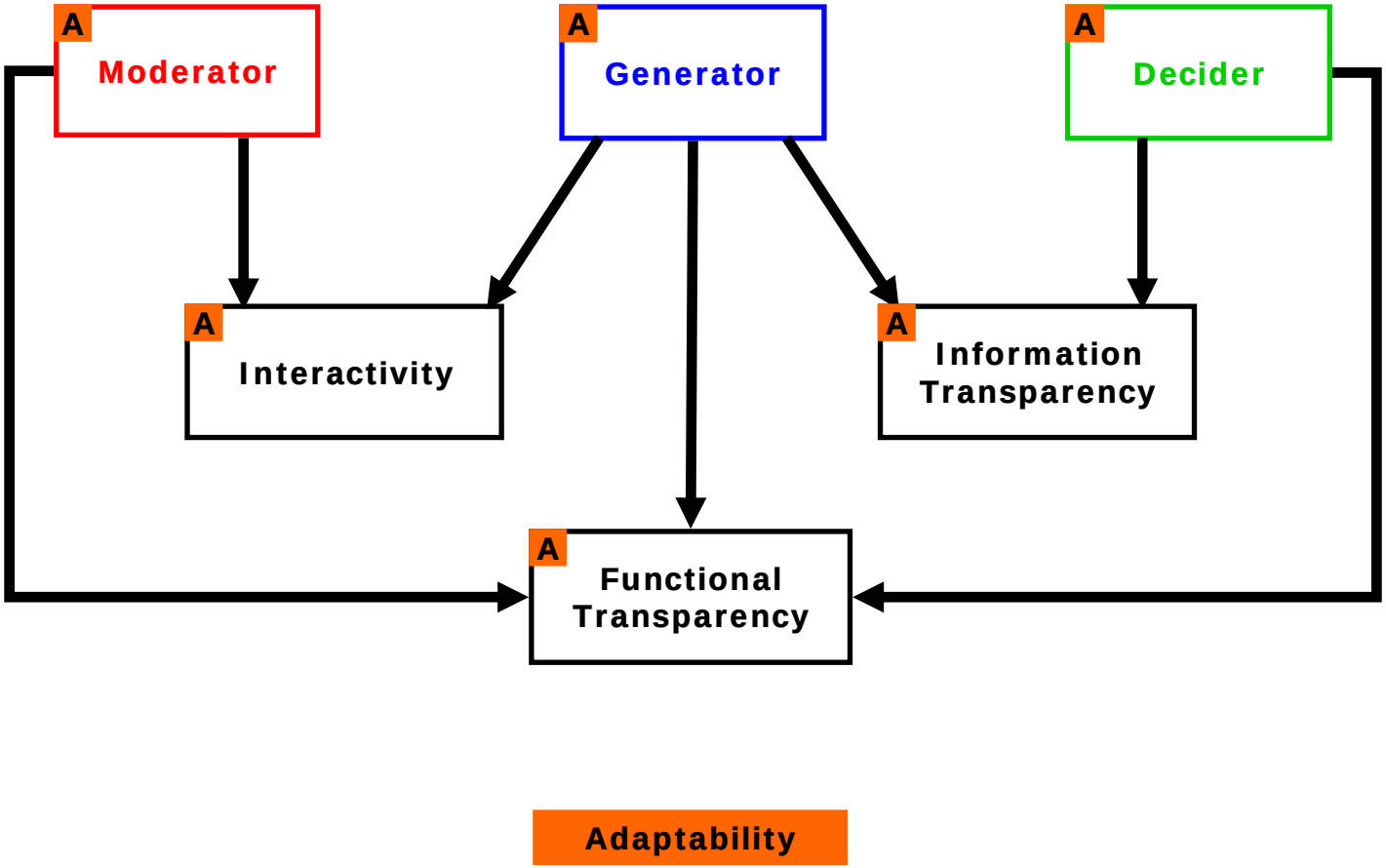
Information Transparency Level	Description
Raw	The agents collaborate using unprocessed low-level information such as sensor readings or measurements.
Mixed	The agents collaborate using both raw and aggregate information.
Aggregate	The agents collaborate using processed data, such as consolidated sensor measurements into abstract structures like a trend graph or post-imaging processing.

Interactivity

- **How do the agents communicate with one another?**
- Applies to: Moderator, Generator

Interactivity Level	Description
Command	Agents assign orders to the other. The recipient may provide confirmation and/or feedback regarding the outcome of the command. At this level, agents unilaterally solicit actions.
Dialogue	Both agents are engaged in a back and forth discussion (two-way communication)

Relations between roles and characteristics

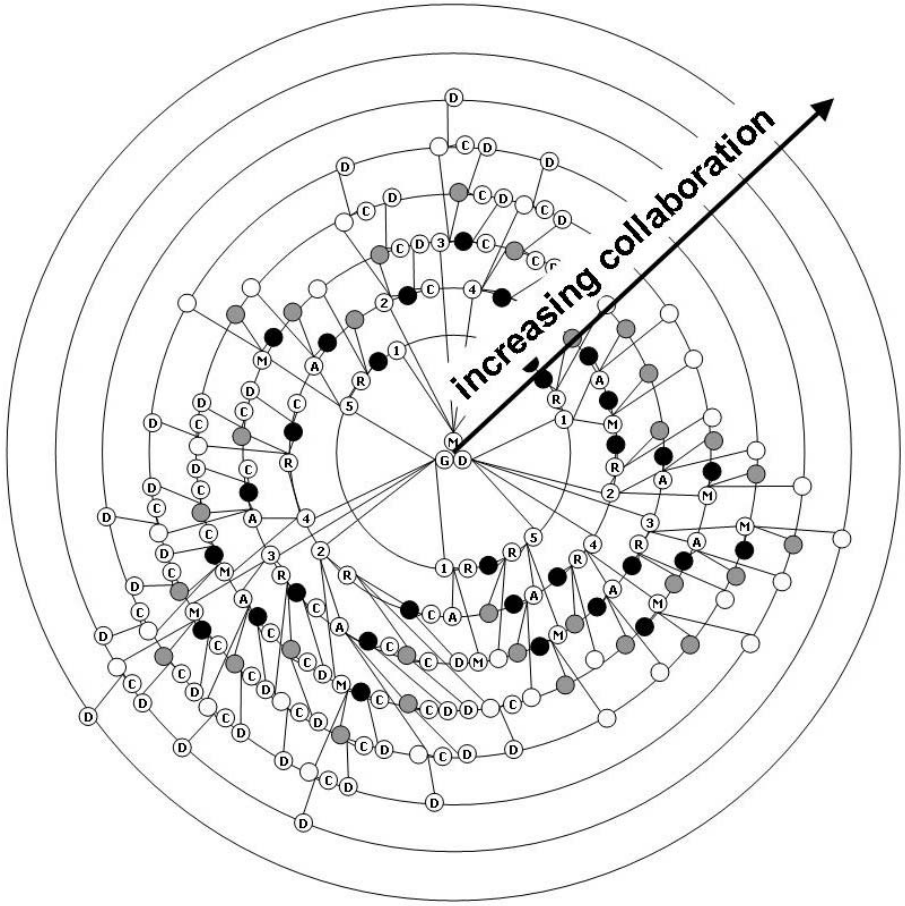


Adaptability

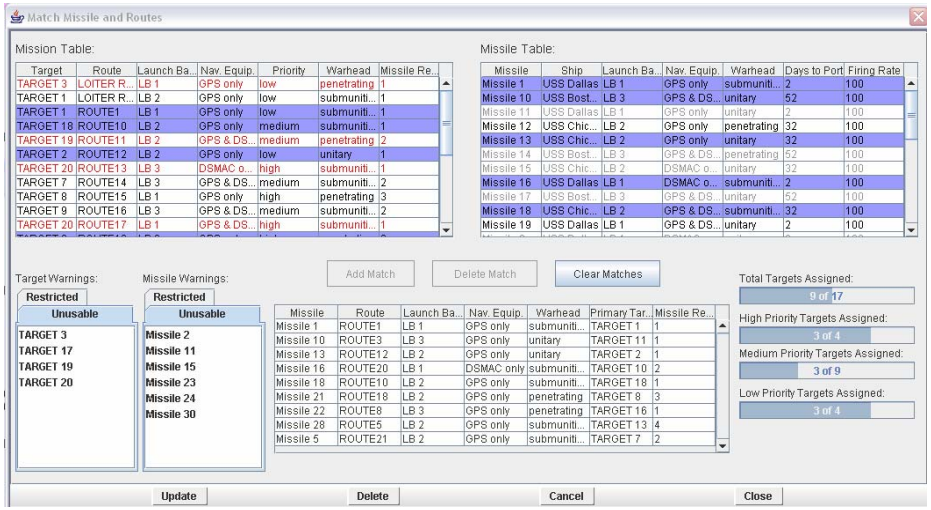
- Cross-cutting attribute to basic roles and primary characteristics
- Comprises three pieces of information:
  - What is the **default level**?
  - What **other levels** are possible?
  - Who can **trigger a change** in level?
    - Human
    - Automation
    - Both

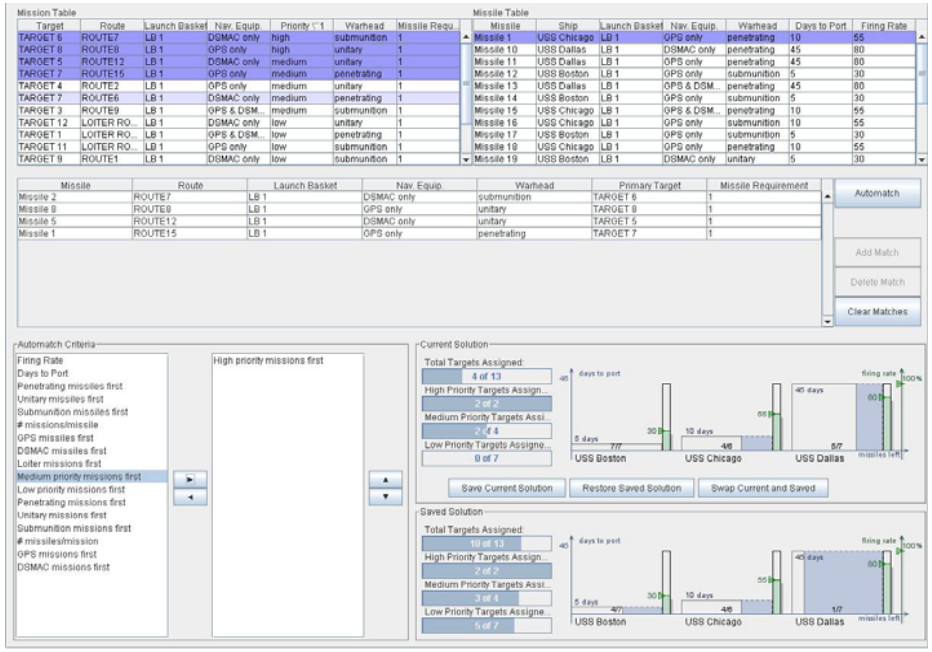
Visualizing collaboration

- "How much" collaboration does a system have?
- Tree representation:
  - nodes = characteristics
  - links = collaboration "weight"
  - each branch shown represents a possible configuration of the system (adaptability)
  - the further out the leaves are, the more collaboration the system features
- Illustration with example



TLAM strike planning using StrikeView





Interface 1 : mostly manual

- human picks missile, mission
- basic automation: filtering, sorting summarizing, status

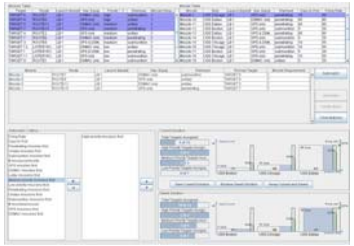
Interface 2 : collaborative

- manual matching
- customizable heuristic search with user-specified criteria
- option to save, graphical feedback

HACT applied to StrikeView

Interface 1

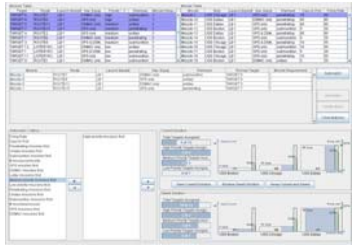
	Moderator (M)	Generator (G)	Decider (D)
Scale level of role	1	2	1
Primary characteristics			
Functional Transparency	n/a	black	black
Information Transparency	n/a	raw	raw
Interactivity	n/a	command	n/a
Secondary characteristic			
Adaptability	no	no	no

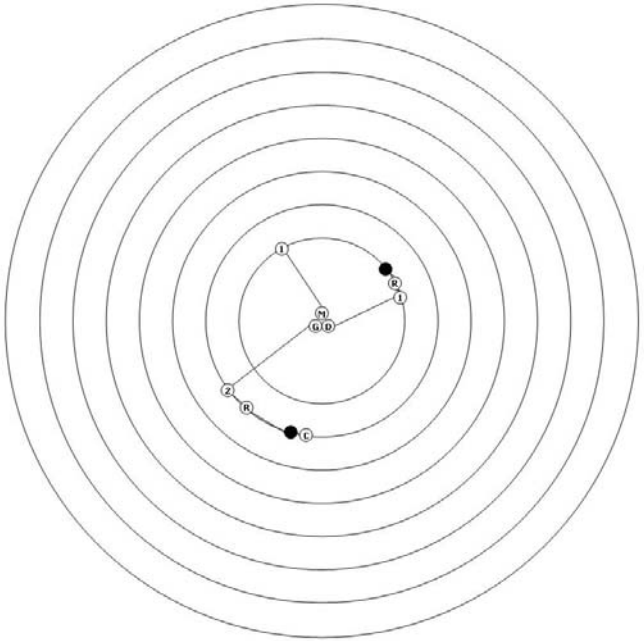


Interface 2

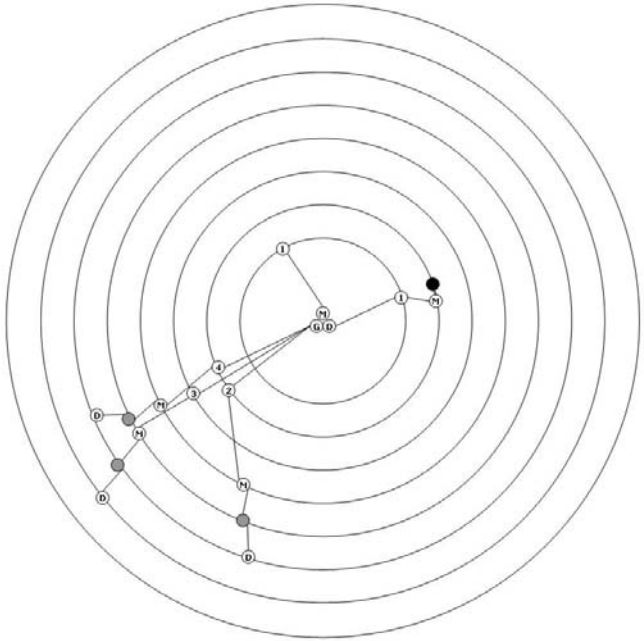
	Moderator (M)	Generator (G)	Decider (D)
Scale level of role	1	2 - 3 - 4	1
Primary characteristics			
Functional Transparency	n/a	grey	black
Information Transparency	n/a	mixed	mixed
Interactivity	n/a	dialogue	n/a
Secondary characteristic			
Adaptability	no	yes	no

HACT visualization





Interface 1



Interface 2

Thank you! Questions?

Acknowledgements

- Research supervised by Prof. M. L. Cummings

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